

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
OFFICE OF SCIENCE AND TECHNOLOGY
METEOROLOGICAL DEVELOPMENT LABORATORY

**MDL SOFTWARE DEVELOPMENT PROCESS (SDP)
FOR THE FORECAST EVALUATION PROJECT**

DRAFT
May 7, 2004

TABLE OF CONTENTS

Section		Page
1.0	Introduction.....	1
1.2	Document Organization.....	1
1.3	Supporting Documents.....	2
2.0	Project Organization and Responsibilities.....	3
2.1	Forecast Evaluation Project Definition Overview.....	3
2.3	Other Organizations and Contractors.....	3
3.0	Project Management.....	4
3.1	Responsibilities.....	4
3.2	Management Process.....	4
3.2.1	Planning Process.....	4
3.2.2	Project Tracking and Oversight.....	6
4.0	Software Development Process.....	7
4.1	Responsibilities.....	8
4.2	Metrics.....	9
4.3	Detailed Software Process Activities.....	10
4.3.1	Requirement Analysis.....	10
4.3.2	Design.....	11
4.3.3	Code and Unit Testing.....	13
4.3.4	Software Integration Testing.....	14
4.3.5	System Integration Testing.....	15
5.0	Documentation.....	16
5.1	Formal Documentation.....	16
5.2	Informal Documentation.....	17
5.3	Software Development Files.....	17
6.0	Reviews.....	18
6.1	Peer Reviews.....	18
6.2	Code Walkthroughs.....	19
6.3	Management Reviews.....	19
6.3.1	Project Status Reviews.....	19
6.3.2	Development Reviews.....	19
7.0	Testing.....	21
8.0	Configuration Management.....	22
9.0	Software Standards.....	23
10.0	Environment.....	24
10.1	Development and Testing.....	24
10.2	Operational.....	24
11.0	References.....	24

TABLE OF CONTENTS (continued)

Figures

Figure 4.0-1	Data Flow of Software Development Process.....	7
Figure 4.1-1	Development Organization.....	9

Tables

Table 3.2.1-1	Planning Input and Output, Entrance and Exit Criteria, Process Control, and Metrics.....	5
Table 4.3.1-1	Requirements Analysis Input and Output, Entrance and Exit Criteria, Process Control, and Metrics.....	11
Table 4.3.2-1	Design Input and Output, Entrance and Exit Criteria, Process Control, and Metrics.....	12
Table 4.3.3-1	Code and Unit Testing Input and Output, Entrance and Exit Criteria, Process Control and Metrics.....	14
Table 4.3.4-1	SWIT Input and Output, Entrance and Exit Criteria, Process Control, and Metrics.....	15
Table 4.3.5-1	SIT Input and Output, Entrance and Exit Criteria, Process Control, and Metrics.....	16

MDL SOFTWARE DEVELOPMENT PROCESS FOR THE FORECAST EVALUATION PROJECT

1.0 INTRODUCTION

The Meteorological Development Laboratory (MDL) Software Development Process (SDP) for the Forecast Evaluation project establishes the software and development processes that are used throughout the software development life cycle. This document describes the processes and procedures that are used to design, implement, and test software.

1.1 DOCUMENT ORGANIZATION

The SDP is organized into the following ten sections.

Section 1 - The Introduction presents the purpose and scope of the plan, an overview of the project, and related documentation.

Section 2 - The Project Organization and Responsibilities section discusses the project organization and the roles and responsibilities for Forecast Evaluation and other organizations that interface with Forecast Evaluation during the development process.

Section 3 - The Project Management section describes a standard approach and mechanism for project managers to plan, track, and measure the software development process.

Section 4 - The Software Development Process section presents an overview of the software development life cycle and describes the major activities in each life cycle phase. It establishes the software development process, methods, and standards to be used in the development of Forecast Evaluation software.

Section 5 - Documentation describes documentation created and the method for the retention of that documentation.

Section 6 - Reviews describes the types of reviews, what is being reviewed, when reviews are employed, and policies and procedures associated with each review.

Section 7 - Testing explains the concept and activities employed in testing Forecast Evaluation software.

Section 8 - The Configuration Management section describes the concepts and activities used for the management of the software development and test products.

Section 9 - Software Standards identifies the standards pertaining to software development including coding standards and design rules.

Section 10 - The Environment section describes the tools, hardware and software environments used to develop and test Forecast Evaluation software.

1.2 SUPPORTING DOCUMENTS

Other important documents related to the SDP include:

MDL Standards, Guidelines and Procedures (NWS 2003a) - This document contains the software standards used in the development of Forecast Evaluation software and contains the set of procedures and guidelines to be used by the development team to standardize the development process and ensure that it is a repeatable process.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

This section describes the responsibilities within the Forecast Evaluation project and the Government and Contractor organizations that interface with the project during the development of application software.

2.1 FORECAST EVALUATION PROJECT DEFINITION OVERVIEW

The Forecast Evaluation project develops and maintains systems to verify official National Weather Service (NWS) forecasts (in accordance with plans developed by the National Verification Integrated Work Team.) The project develops, evolves, and maintains systems to collect and verify a variety of NWS forecasts, including the AWIPS Verification Program (AVP) and forecasts from the National Digital Forecast Database (NDFD). Future plans include data collection and processing systems to verify official NWS public and aviation forecasts.

2.2 OTHER ORGANIZATIONS AND CONTRACTORS

Forecast Evaluation staff must interface regularly with other organizations inside and outside of MDL that play a critical role in the development and deployment of software. These organizations include:

RS Information Systems (RSIS) - They are responsible for managing and staffing MDL's system administration group.

Office of Science and Technology (OST) - OST has overall management responsibility for the MDL programs.

OST/MDL/Statistical Modeling Branch (SMB) - SMB is responsible for incorporating changes into the baseline version of the Model Output Statistics (MOS) 2000 software. Code is shared between the Forecast Evaluation project and MOS project necessitating coordination and interaction.

OST/MDL/Mesoscale Prediction Branch (MPB) - MPB is responsible for incorporating changes into the baseline version of the National Digital Forecast Database (NDFD), including contents of the NDFD and associated encoding software. NDFD verification work depends on the proper interpretation and decoding of the data necessitating coordination and interaction.

Office of Climate, Water and Weather Services (OCWWS)/Performance Branch (PB) - PB is responsible for directing the legacy AWIPS Verification Program, establishing NWS policies, coordinating with field offices and regional headquarters, and directing the development of future NWS verification systems. The Forecast Evaluation project implements changes to its systems when necessary based on policies set by the PB.

NWS Verification IWT and/or Digital Services IWT - These advisory groups recommend procedures for verifying digital forecasts. The Forecast Evaluation project implements changes to its systems or designs new systems based on recommendations set by these groups.

3.0 PROJECT MANAGEMENT

This section describes a standard approach and mechanism for project managers to plan, track, and measure the software development process.

3.1 RESPONSIBILITIES

The roles and responsibilities of project management are described below.

Director, MDL - Overall responsibility for the software development effort.

Project Manager - The Project Manager is responsible for reviewing the plans, making the project commitments, and reviewing any changes. Specifically, the Project Manager oversees cost, schedule, and interfaces with other NWS organizations.

Task Manager - The Task Manager leads the development of the task. He/she coordinate the activities of the developers and reviewers. The Task Manager performs the requirement analysis, assists with the design, reviews developers' code and test procedures, and assists in the preparation of test matrices and schedules. The Task Manager reports to the Project Manager.

3.2 MANAGEMENT PROCESS

Managing a software project requires careful planning, control of activities, and tracking against the planned activities. Once a plan is developed, the actual activities are tracked against the plan to determine whether there is any deviation from the plan. Metrics (as defined in Section 4.2) are used to measure performance and suggest process improvement.

This management process will mature as the program progresses. This means that the plans are living documents. This management process emphasizes early planning and risk analysis. The plans are reviewed, revised, and expanded based on the most recent knowledge of the program at key milestones, when the scope changes, and at regular intervals.

3.2.1 PLANNING

Software planning involves developing estimates for the work to be done, establishing the necessary commitments, and defining a plan to complete the work. The plan provides the basis for initiating the software effort and managing the work. Accurate estimations of cost and schedule up front and adherence to required staffing levels and equipment usage are a key factor to completing a project within budget.

Planning is a continuous process. As the design proceeds, certain design decisions may change the plan or schedule. As change requests (e.g., new deficiencies, enhancements, or requirements) are identified, the process must be repeated and documentation produced describing the impact of any changes to the cost and schedule.

The following functions are required during the Planning step. The responsible party for each function is shown in **bold** type.

Prepare Forecast Evaluation Change Requests - Forecast Evaluation Change Request (FECRs) can be prepared by **Project Manager, Task Manager or Developer** for new requirements, enhancements, software deficiencies, hardware and system changes.

Create Tasks - If necessary, tasks are prepared by **Task Manager** for new requirements, enhancements, hardware and system changes. Tasks are linked to FECRs.

Estimate Level of Effort (ELOE) - For each task the **Task Manager** estimates the size of the task and the ELOE. The size of the task includes the number of software components required and lines of code. The ELOE is measured by estimating the number of labor hours required to develop, test, document, and maintain the software.

Prepare Project Tracking Information (PTI) - The **Task Manager** prepares a Staffing Plan and Development Schedule.

See the MDL Standards, Guidelines, and Procedures (NWS2003a) for a PTI template.

Table 3.2.1-1 describes the input, output, entrance and exit criteria, process controls and metrics for this Planning step along with the responsible parties.

Table 3.2.1-1. Planning Input and Output, Entrance and Exit Criteria, Process Controls and Metrics

Title	Description	Responsibility
Entrance Criteria	Forecast Evaluation Change Request Form prepared	Project Manager, Task Manager, Developer
Input	Forecast Evaluation Change Request received Other development schedules	Task Manager, Project Manager, Developer
Output	Project Tracking Information (PTI)	Task Manager
Exit Criteria	PTI completed	Task Manager
Process Controls	Management reviewed	Project Manager
Metrics	To Be Determined (TBD)	

3.2.2 PROJECT TRACKING AND OVERSIGHT

Software tracking and oversight involve tracking and reviewing software progress against the documented estimates, schedules, and plans, and adjusting these based upon the actual data. This activity occurs throughout the development effort.

Software tracking and oversight start as soon as the effort commences. The development schedules are used as the basis for tracking and oversight throughout the development life cycle. During development, actual data are collected according to the process model. These data are analyzed at specified intervals against the plan. If the actual status of the program deviates beyond an acceptable norm, corrective action is taken. Corrections made to schedule, cost, or software sizes are reviewed with respect to each other. Then, the schedule and any renegotiated commitments are revised and reviewed.

When modifying the schedule, the Software Manager (SM) keeps records that explain the reasons for various corrective actions and the rationale for that change. This information is useful for developing the lessons learned and other postmortem analysis.

The following are reviews that are established to track development schedule.

Status Reviews - Status reviews, if necessary, are conducted with the Task Manager and developer to review progress and address issues. These can be conducted weekly or biweekly depending on the wishes of the Task Manager.

Planned Reviews - Planned reviews are conducted at key periods during the development cycle to review requirements, design, coding, testing, and delivery. In addition, reviews are conducted to review code (e.g., code walkthrough) and other development products (e.g., peer reviews). See Reviews (Section 6.0) for more information on these reviews.

Forecast Evaluation Staff Meeting - The Project Manager and Task Manager meet as needed to review progress, address issues, and coordinate activities.

In addition, the following information is used by the Task Manager to provide tracking and oversight, and facilitate reporting to other NWS organizations.

Project Tracking Information (PTI)

- Development Schedule - High level schedule showing the development activities (e.g., requirement review) and major checkpoints on a time line.
- Staffing Plan - List of tasks per release with estimated level of effort and identified Task Manager and development staff.
- Development Checklist - Internal detailed checklist employed by management to track development progress and adherence to the MDL Software Development Approach requirements (NWS 2004).

See the MDL Standards, Guidelines, and Procedures (NWS2003a) for a PTI template.

Metrics - Information to guide process improvement (See Section 4.2).

4.0 SOFTWARE DEVELOPMENT PROCESS

This section describes the software development and maintenance process in detail. Below are the major activities that should be accomplished during the development of software.

- Requirements Analysis
- Design
- Coding and Unit Testing
- Software Integration Testing
- System Integration Testing

Some of these activities may not be necessary for specific types of projects. The process is flexible and can be ordered to fit any of the popular paradigms of software architecture including Waterfall, Rapid Prototype, or Evolutionary models. Figure 4.0-1 shows the typical waterfall software development process sequence with interrelationships, and significant checkpoints and reviews.

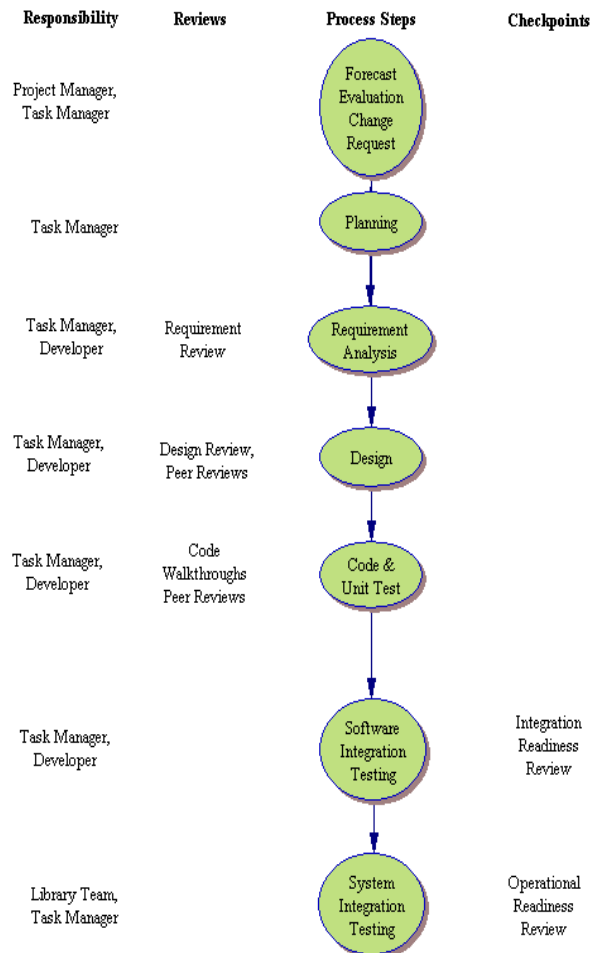


Figure 4.0-1: Data flow of the Software Development Process.

4.1 RESPONSIBILITIES

The development organization of shown in Figure 4.1-1 and defined below. Depending on the size of the development effort, a staff member may be tasked with multiple roles.

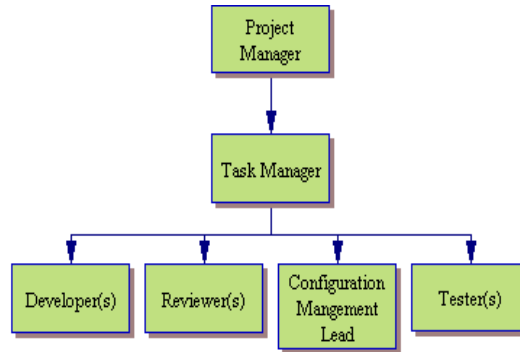


Figure 4.1-1. Development Organization

Task Manager - The Task Manager's leads the development of the task. The Task Manager coordinate the activities of the developers and reviewers. The Task Manager performs the requirement analysis, assists with the design, reviews code and test procedures, and assists in the preparation of test procedures. The Task Manager reports to the Project Manager.

Developer - The Developer's major responsibility is to code software using the established coding standards, guidelines and procedures. After completing the coding phase, the Developer goes through the code review process with their Task Manager. The Task Manager and Developer are responsible for creating test procedures, and performing the unit testing. The Developer is responsible for preparing all necessary external documentation.

Reviewers - The Reviewers role is to participate in the various reviews described in Section 6.0 of this document. The reviewers can be the Task Manager, technical staff members, developers, specialists or users whose backgrounds give them insight into the material to be discussed.

Tester - A developer, assigned by the Task Manager, preferably someone other than the developer who wrote the code.

Configuration Management Lead - The CM Lead manages version control for the Forecast Evaluation software and interacts with the MOS Library Team.

4.2 METRICS

The Project/Software Managers use software metrics gathered to evaluate key characteristics of the software being developed, the process employed, and the milestones. A successful metrics program depends on accurate and consistent data collection and presentation. The validity of the data should be determined prior to any analysis activity. Under these circumstances, the metrics can provide early warning of potential software development problems. In turn, this should lead to early problem resolution.

Graphic presentation of the metrics can reveal developing trends, which, when analyzed as related sets, highlight anomalies that might otherwise be overlooked. Management can then determine their significance and corrective action can be taken. Results are used to improve the ongoing project and are reported at management reviews.

Types of metrics include number of software requirements, number of software requirement changes, product size, level of effort, cost, schedule, defects and computer resource utilization. In the future, MDL will develop composite metrics to indicate productivity, quality, production rate and stability.

Metrics used by Forecast Evaluation are identified in Section 4.3 of this document.

4.3 DETAILED SOFTWARE PROCESS ACTIVITIES

For each step in the process, this document defines:

Entrance Criteria - criteria needed to start the activity,
Input - products dependencies of the step,
Functions - process and tasks of each step,
Metrics - set of measurement data resulting from the work products,
Responsibility - who is responsible for completing that activity,
Output - products of activity,
Exit criteria - criteria for completing the activity, and
Process controls - controls put into place to insure quality.

Guidelines and process descriptions necessary to complete the activity are kept in the MDL Standards, Guidelines and Procedures (NWS 2003a).

4.3.1 REQUIREMENTS ANALYSIS

The software development processes are requirements driven. Requirements are a formal statement of an attribute to be possessed by the product or a function to be performed by the product. These requirements form a written agreement between developer and customer. Requirement analysis provides a means for establishing and maintaining requirements so that both the customer and the developers are working from the same set of expectations.

The completion of the Planning (Section 3.2.1) activity results in a task(s) being assigned to a Task Manager or Developer. The Task Manager or Developer defines and develops software requirements and prepares a Requirements Description (RD). The Requirement Description is a set of detailed software requirements derived from the Forecast Evaluation Change Request. Requirements can address operation concepts, functional and user interface specifications, performance and capability, external interfaces, security, error handling, installation, configuration, language, maintenance, and the use of legacy software. For data-driven and data-intensive systems, the Requirement Description can include data sources, types, and rates.

A Requirement Review is held to finalize the understanding of requirements with the Task Manager and obtain approval.

Note that requirements can be dynamic and change as the design is evaluated and development is conducted. As these changes occur, the changes should be made to the Requirements Description and those changes presented at the appropriate review.

The following functions are required during the Requirements Analysis step. The responsible party for each function is shown in **bold** type.

Define and develop software requirements - The **Task Manager or Developer** defines the set of software and derived requirements for this project and prepares a Requirement Description.

Analyze requirements - A peer review is conducted by the **Task Manager or Developer** to analyze the requirements to ensure, at a minimum, traceability, completeness, clarity, testability, safety, and validity.

Perform Requirements Review - A Requirements Review is conducted by the **Task Manager or Developer**. Participants should include **Task Manager**. Action items (if necessary) are documented and delivered to the approval body and tracked through closure by the **Task Manager or Developer**.

Approval - The Requirements Review is formally approved by **Task Manager** and/or the **Project Manager**. The approval can be provided verbally, in an email, or memo.

Update Forecast Evaluation Change Request (FECR) - The **Developer** updates the FECR upon completion of this phase.

Update Project Tracking Information (PTI) - The **Task Manager** updates the Development Schedule and staffing with any changes that result from a better understanding of the requirements.

Table 4.3.1-1 describes the input, output, entrance and exit criteria, process controls, and metrics for this Requirements Analysis step along with the responsible parties.

Table 4.3.1-1. Requirements Analysis Input and Output, Entrance and Exit Criteria, Process Controls, and Metrics

Title	Description	Responsibility
Entrance Criteria	Development schedule prepared	Task Manager
Input	Forecast Evaluation Change Request	Project Manager, Task Manager, Developer
Output	Requirements Description	Task Manager, Developer
Exit Criteria	Requirements Description approval	Task Manager and/or Project Manager
Process Controls	Requirements Review Management Approval	Task Manager, Project Manager
Metrics	TBD	

4.3.2 DESIGN

The Design phase will establish a complete software design to be used by the developers of the software. The software components are defined in terms of purpose, use cases, interfaces, data requirements, data structure, error handling, storage and throughput, timing requirements, and diagnostic considerations. The relationship of components is defined in terms of data flow between them and external interfaces, and the control flow between components.

A Design Review is held to finalize the understanding of design and obtain approval to code the software. Approval of the design is provided by the Task Manager.

The following functions are required during the Design step. The responsible party for each function is shown in **bold type**.

Define software components - The **Task Manager or Developer** defines the set of software components to be developed or modified.

Prepare design - The **Task Manager or Developer** defines components and interfaces, relationships and data flows, physical structure, user interface, data structure, and critical test scenarios.

Peer Review - Peer reviews are conducted by the **Task Manager or Developer** to review selected design components. Participants could include the Task Manager and other Developers.

Perform Design Review - A Design Review is held to understand a basic design when new software development is undertaken for either developmental or operational codes. No strict process is followed. The review process depends on the code that needs to be written. If a developmental code that needs to be completed does not deviate much from a previous code, the review process is very informal. A more extensive review is undertaken in instances when a code departs extensively from previously written software.

A Design review is conducted by the **Task Manager or Developer**. Participants should include Project Manager. Action items (if necessary) are documented and delivered to the approval body and tracked through closure by the **Task Manager or Developer**.

Approval - The Design Review is formally approved by the **Project Manager and Task Manager**. The approval can be provided verbally, in an email, or memo.

Update Forecast Evaluation Change Request (FECR) - The **Task Manager or Developer** updates the FECR upon completion of this phase.

Assign developers - The **Task Manager** assigns developers to the software components.

Update Project Tracking Information (PTI) - The **Task Manager** updates the Development Schedule.

Table 4.3.2-1 describes the input, output, entrance and exit criteria, process controls, and metrics for this Design step along with the responsible parties.

Table 4.3.2-1. Design Input and Output, Entrance and Exit Criteria, Process Controls, and Metrics

Title	Description	Responsibility
Entrance Criteria	Requirements Description Approval	Task Manager,
Input	Requirements Description	Task Manager, Developer
Output	Design documents	Task Manager, Developer
	Updated Project tracking Information (PTI)	Task Manager
Exit Criteria	Design completed	Task Manager, Developer
	PTI update	Task Manager
	Design approved	Task Manager, Project Manager
Process Control	Design Review	Task Manager

Metrics	TBD	
---------	-----	--

4.3.3 CODE AND UNIT TESTING

Once the Design Review is approved, the developers assigned to the Coding activity can begin.

Coding is performed uniformly across software products using defined standards and guidelines. The objectives of source code written are as follows:

- Meets requirements
- Contains correct logic and interfaces and handles data structures properly as specified in the design documentation
- Complies with coding standards
- Compiles successfully without any warning or error messages
- Follows good coding techniques
- Includes proper internal documentation
- Follows reasonable and understandable size limitations
- Considers reuse, portability, and system independence

The following functions are required during the Code and Unit Testing step. The responsible party for each function is shown in **bold** type.

Prepare code - The code is created or modified by the **Developer** according to the design documents and MDL Standards, Guidelines and Procedures (NWS 2003a).

Create Test Procedures - Test procedures are created by the **Task Manager and Developer** to test the modification to the code. Additional test procedures are identified to ensure the modification has not affected the existing code. Test Procedures should be prepared in accordance with the MDL Standards, Guidelines and Procedures (NWS 2003a).

Test Procedure Peer Review - The **Developer** should conduct a peer review of the test procedures.

Perform Unit Testing - The **Developer** should perform unit testing in accordance with Section 2.1.1 of the MDL Test Process (NWS 2003a). In most instances, the software developer is responsible for checkout of the software to ensure functionality. It is the responsibility of the developer to be sure that answers are correctly obtained by comparing the answers of older codes. The **Task Manager** supervises the testing.

Perform Code Walkthroughs - Once the code has been completed and Unit testing has been completed, the **Developer** prepares and performs a Code Walkthrough. Participants in the code walkthrough include the Task Manager. This is typically an informal process, however, a Code Walkthrough form needs to be filled out and defects recorded.

Fix Defects - The **Developer** fixes defects found during the Code Walkthrough.

Prepare Draft MDL Office Note - The **Developer** prepares a first draft of the MDL Office Note, if necessary.

Update Forecast Evaluation Change Request (FECR) - The **Developer** updates the FECR upon completion of this phase.

Table 4.3.3-1 describes the input, output, entrance and exit criteria, process controls, and metrics for this Code and Unit Testing step along with the

responsible parties.

Table 4.3.3-1. Code and Unit Testing Input and Output, Entrance and Exit Criteria, Process Controls, and Metrics

Title	Description	Responsibility
Entrance Criteria	Design Completed	Task Manager, Developer
Input	Design Document	Task Manager, Developer
Output	Code, Test procedures, Code Walkthrough documentation, Draft Office Note, Development Ticket	Developer
Exit Criteria	Code is tested, walkthrough is completed, defects are addressed, draft office note is completed	Developer
Process Controls	Code Walkthrough	Developer
	Peer Reviews	Developer
Metrics	None	

4.3.4 SOFTWARE INTEGRATION TESTING (SwIT)

The Forecast Evaluation team established an internal process to test software in an integrated environment and maintain developmental software libraries. The Task Manager assigns developer(s) to test the software change.

The following functions are required during the SwIT step. The responsible party for each function is shown in **bold** type.

Assess Forecast Evaluation Change Request (FECR) - The **Task Manager** assesses the code change and insures that the code has gone through each step of the Forecast Evaluation software development process (e.g., design review, code walkthrough).

Assign a Forecast Evaluation Change Request - The **Task Manager** assigns Forecast Evaluation Change Request (FECR) to a member of the Forecast Evaluation team called in this document, a **Tester**.

Run Test Procedures - The **Tester** runs the assigned test procedures for the Code Change Request, records the results and notifies the Developer.

Update Forecast Evaluation Change Request (FECR) - The **Developer** updates the FECR upon completion of this phase.

Conduct an Integration Readiness Review (IRR) - The **Task Manager** reviews the FECR to determine the readiness for System Integration Testing. Participants should include the Project Manager, Task Manager, and Developer. Action items (if necessary) are documented.

Approval - The IRR is formally approved by the **Project Manager and Task Manager**. The approval can be provided verbally, in an email, or memo.

Configuration Management Update - The **CM Lead** will implement the codes as indicated in the FECR, updates the Change Log, README Files in the affected directories, remakes any executables or libraries. The Task Manager and Project Manager are notified that the change has been implemented.

Table 4.3.4-1 describes the input, output, entrance and exit criteria, process controls, and metrics for this SwIT step along with the responsible parties.

Table 4.3.4-1. SwIT Input and Output, Entrance and Exit Criteria, Process Controls, and Metrics

Title	Description	Responsibility
Entrance Criteria	FE Change Request received	Developer
Input	FE Change Request	Developer
Output	Tests are completed and checked out	Tester
Exit Criteria	Testing completed,	Task Manager, Tester
	Integration Readiness Review conducted	Task Manager
	Software is approved	Project Manager
	All versions updated	CM
Process Control	Integration Readiness Review	Task Manager
Metrics	TBD	

4.3.5 SYSTEM INTEGRATION TESTING (SIT)

The Forecast Evaluation project shares a number of software programs with the MOS project. Any MOS changes identified by Forecast Evaluation staff are provided to the MOS Library Team in the form of a Development Ticket. The MOS Library Team is responsible for monitoring and testing MOS software. See Section 4.3.4 of the MDL Software Development Process for MOS Project (NWS 2003b) for more information on that step of the process.

5.0 DOCUMENTATION

Documentation is continually prepared to communicate and archive valuable development information. This information is used by management, system integrators, users, developers, and support and maintenance personnel. It is included as a separate section in this document to emphasize its importance.

All documentation is updated continuously and archived for all software development in the Software Development Files (SDFs).

5.1 FORMAL DOCUMENTATION

This section identifies what formal external documentation is produced for software developed by Forecast Evaluation. Internal documentation requirements and standards are covered under the appropriate software standards described in Section 9.0 of this document.

Requirements Description - Description of the requirements is based on the Forecast Evaluation Change Request (FECR). Guidelines for preparing requirements and a checklist are contained in the MDL Standards, Guidelines and Procedures (NWS 2003a).

Design Document - Documentation used by the Forecast Evaluation team to capture the design of an application. Guidelines for preparing a design and a checklist are contained in the MDL Standards, Guidelines and Procedures (NWS 2003a).

Project Tracking Information (PTI)

- Development Schedule - High level schedule showing the development activities (e.g., requirement review) and major checkpoints on a time line.
- Staffing Plan - List of tasks per release with estimated level of effort and identified Task Manager and development staff.
- Development Checklist - Internal detailed checklist employed by the management to track development progress and adherence to the MDL Software Development Approach requirements (NWS 2004a).

See the MDL Standards, Guidelines, and Procedures (NWS2003a) for a PTI template.

Test Procedures - One or more test procedures are identified to evaluate the functional or structural condition of the code. Test procedures are designed based on specific functional requirements or components of code structure. Each test procedure will identify the software requirements validated by the test. A complete description of test procedures and recommended documentation is contained in the MDL Standards, Guidelines and Procedures (2003a).

Forecast Evaluation Change Request - The Forecast Evaluation Change Request (FECR) documents a software change and follows a change from identification of a requirement, improvement or bug to completion of testing. A FECR includes the following information:

- Ticket number
- Date of Entry
- Status (e.g., COMPLETED)
- Programmer name
- Category of Change (e.g., bug, improvement, requirement)
- Reason for Change
- Codes Affected
- Description of Change Made
- Tester
- Test Procedure
- Test Notes
- Version Control Information
- Platform where change is made

MDL Office Notes - An MDL Office Note is the formal documentation prepared for the software routines under the Forecast Evaluation project. See the MDL Standards, Guidelines, and Procedures (NWS 2003a) for more information concerning the content and style of the Office Note.

5.2 INFORMAL DOCUMENTATION

Informal documentation includes:

- Briefing slides,
- Design information and documentation, including rationale supporting design decisions,
- Peer review, design review, and code walkthrough results, checklists, and comments,
- Test cases and results plus test drivers used, and
- Meeting minutes, memos, action items, checklists, and correspondences.

5.3 SOFTWARE DEVELOPMENT FILES

Software Development Files (SDFs) contain all formal and informal information describing the development or maintenance of the software product. The SDF should be maintained online as much as possible, to facilitate searching and inclusion into documentation. It may contain media copies or references to controlled media copies of supporting data.

6.0 REVIEWS

This section defines the process for the four types of internal reviews that are performed during the development of software. These reviews are categorized as:

- Peer reviews
- Code walkthroughs
- Project Status Reviews
- Development Reviews

Some of these reviews are conducted internal to Forecast Evaluation and, in most cases, do not include customer participation. Typically, the reviews addressed in this section lead up to development reviews (e.g., design reviews).

Our experience has proven the effectiveness of internal reviews throughout the software development and maintenance process. This is an extremely cost-effective approach for early identification and resolution of technical and management problems and improved communication within the software project team. Furthermore, the types of reviews defined in this section work equally well on all sizes and types of software projects. However, each type of review must be exercised in an appropriate manner, as defined in this section, or substantial benefits may be degraded.

The Software Manager responsibility includes participation in selected reviews, usually as an observer, and verification that the reviews are taking place in conformance with the process. This responsibility includes periodic auditing of selected SDFs to ensure that the material is updated and current.

6.1 PEER REVIEWS

Peer reviews are conducted according to a documented procedure. Staff is trained in peer review objectives, principles, and methods from the perspective of both leader and participant.

The concept behind peer reviews is that the author/developer of a product (i.e., specification, design, unit of code, test procedures) gets help from a colleague who is familiar with the product. Together, they discuss in detail a specific portion of the overall product. The author presents the product element to the colleague, item by item, who in turn raises questions and suggestions. Application of the concept is simple and inexpensive. One-on-one reviews are ad hoc. They are accomplished with only enough planning necessary to solicit participation from the colleague and prepare the product element to a state where it can be reviewed. Such reviews should always be limited to two hours. Peer reviews usually examine a portion of a product rather than the entire document, plan, specification, or design under review. Because peer reviews impose only small blocks of time, this technique is used frequently (typically many times in a given week) among the set of people working that project. Notes are kept by the author of the product element. No "list of issues" or action items result from peer reviews.

The MDL Standards, Guidelines, and Procedures (NWS 2003a) contains guidelines on how to conduct peer reviews.

6.2 CODE WALKTHROUGHS

Similar to peer reviews, code walkthroughs involve only technical staff. The number of participants, counting the product author, ranges from three to six. Scheduled code walkthroughs have a maximum duration of two hours. The focus is on identifying technical issues and concerns, not solutions. As discussed below, a moderator is assigned to keep the review focused only on technical issues, rather than discussing solutions to issues. A list of the identified issues is made during the review.

Follow-up code walkthroughs are conducted as appropriate to the importance of the identified issues. The list of issues packaged with a minimal amount of data about the review itself (e.g., date and members) are placed in the Software Development Files (SDFs) for the product that was partially or fully reviewed.

The MDL Standards, Guidelines, and Procedures (NWS 2003a) contains guidelines on how to conduct code walkthroughs.

6.3 MANAGEMENT REVIEWS

Management is responsible for resolving the technical, schedule, and resource issues that are a significant risk to the project. Primary communication and resolution mechanisms used by management are Project Status Reviews.

6.3.1 PROJECT STATUS REVIEWS

Project Status Reviews occur both on a periodic and event-driven basis. Participants can include Forecast Evaluation team members, Task Manager, and Project Manager. Technical progress, plans, performance, and issues are discussed and tracked against the baselined project plans. Each attendee presents a summary of activities and issues since the last Project Status Review as well as plans for the upcoming period. The meeting focuses on open, significant issues. Anyone can present alternative solutions for those significant issues.

Task Manager should record all issues identified at the meeting as requiring resolution. An action list is distributed by the **Task Manager** to the meeting attendees. The **Task Manager** maintains the list and detailed records of how each issue was resolved.

6.3.2 DEVELOPMENT REVIEWS

Development Reviews are conducted upon the completion of a formal milestone and should be performed in accordance with a documented procedure contained in the MDL Standards, Guidelines, and Procedures (NWS 2003a). Development reviews include:

Requirements Review - Presentation and request for approval of requirements.

Design Review - Presentation and request for approval of design information.

Integration Readiness Review - The purpose of the Integration Readiness Review (IRR) is to evaluate the software readiness to proceed to an operational platform for implementation. The IRR is performed by the **Task Manager**. The evaluation process involves reviewing the test results of Software Integration Testing and to ensure all defects are either corrected and tested or have been reassigned to a later release. A satisfactory resolution of test procedures is essential before approval. This review should include:

- Verify that all development steps were completed
 - including code walkthroughs
- review of the code to verify it meets Forecast Evaluation standards
- review of test procedures to verify that the software was adequately tested
- perform ad-hoc testing of the software
- verify documentation is complete
 - Office Note, when appropriate
 - Forecast Evaluation Change Request (FECR)

7.0 TESTING

The primary goal of all of the testing activities is to identify and remove defects and to provide a standard approach for testing the Forecast Evaluation software.

The Forecast Evaluation Test program is based on the following key concepts:

- The testing approach is to provide an effective, repeatable, software test process which is independent of the software language, design methodology, and development environment,
- The testing scope is to identify and remove all defects and also to validate that the software applications meet all requirements allocated to them,
- The testing strategy incorporates two basic points of view: functional (user's) and structural (program attributes). The testing of each application will be designed to include adequate coverage of both the functional and structural aspects,
- The testing process will essentially follow a bottom-up approach. The testing will begin at the lowest unit level and proceed upward as units are integrated into the application. Regression testing will be performed when appropriate, and
- Quality is designed into products using defined processes that are continually monitored and updated to improve their efficiency, to avoid recurring problems, and to maintain the desired quality of resulting products.

The MDL Test Process contained in the MDL Standards, Guidelines, and Procedures (NWS 2003a) describes the criteria, test strategy (i.e., test cases, procedures, level of testing) necessary to provide an effective, repeatable software test process which is independent of the test environment.

8.0 CONFIGURATION MANAGEMENT

The Configuration Management (CM) function ensures that the software development process is followed and that the necessary metrics are collected.

The CM program is based on the following key concepts:

- The tools used are customized to the defined development life cycle,
- All code changes are documented and related to the appropriate change document, and
- The change documents are customized to collect the necessary metrics and to provide management, developers, and users with the appropriate information in a timely manner, so as to identify risks as early as possible.

The Forecast Evaluation team uses a series of change logs associated with each version of Forecast Evaluation. These change logs include:

Forecast Evaluation Change Requests (FECR) - used to track a variety of information for each code change (See section 5.1 of this document).

README Files - files associated to each version describing:

- the date of the change, programmer, and description

9.0 SOFTWARE STANDARDS

The critical importance of developing well documented and well-structured code has become more obvious with time. Except for, possibly, some small programs/subroutines written exclusively to test an idea or structure that will soon be discarded, Government developed software will be inherited and maintained by others. It is imperative to follow good coding and documentation rules in the development of all code, and in particular code that is to be handed off for use outside of MDL. Reasons include:

- With several people involved in a project, it is important that guidelines be followed so that all can easily "read" another person's program,
- Usually, it will fall to someone other than the originator to modify or maintain a program at some time in the future. Again, if a program has been written and documented according to prescribed rules, revisions and maintenance are much easier,
- Standardization will reduce errors in coding. The eye and mind become accustomed to "patterns," and a break in a pattern may be an error,
- Converting a body of software from one computer system to another is easier if it is all written and documented to the same standards, and
- New employees with little or no programming experience can be more easily trained in good procedures if those procedures are written down and everyone follows them.

In summary, the objectives of these guidelines are to enhance clarity, testability, maintainability, and person-to-person and computer-to-computer transferability of software throughout its life cycle. The following standards are contained in the MDL Standards, Guidelines, and Procedures (NWS 2003a):

- MDL FORTRAN Standards
- NCEP FORTRAN Standards
- C,
- C++,
- Tcl/Tk,
- Python,
- scripts, and
- HTML.

10.0 ENVIRONMENT

10.1 DEVELOPMENT AND TESTING

The development and testing environment for MDL consists of legacy HP running a variety of X software applications. The following HP equipment, broken out by floor, is used for development:

SSMC2 10th floor - BLIZZARD, ICE

NCEP - the IBM eServer P690 and FAStT500 Storage server that uses a FORTRAN 95 compiler on an AIX UNIX platform.

SSMC2 7th floor -

10.2 OPERATIONAL

NCEP - the IBM eServer P690 and FAStT500 Storage server that uses a FORTRAN 95 compiler on an AIX UNIX platform.

11.0 REFERENCES

National Weather Service, 2003a: MDL Standards, Standards, Guidelines and Procedures for AWIPS, Meteorological Development Laboratory, Office of Science and Technology, NWS, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, (draft).

National Weather Service, 2004: MDL Software Development Approach, Meteorological Development Laboratory, Office of Science and Technology, NWS, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, (draft).